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ONTARIO

DEPARTMENT OF EDUCATION

Courses of Study

Grades 11 and 12

SCIENCE

AND

AGRICULTURAL SCIENCE

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COURSES OF STUDY

for

GRADES 11 AND 12

in

Collegiate Institutes, High and Continuation Schools

SCIENCE

The Science of Grades 11 and 12 is an experimental study, and emphasis should be based on pupil experiments throughout the course. Accuracy and precision in making observations, taking measurements, and reaching conclusions are the main desiderata. Encouragement should be given to the recording of experiments by means of simple line diagrams, supplemented by very brief notes. Time should not be wasted in writing notes from dictation or in copying material from text or manual.

GRADE 11

PHYSICS

OBLIGATORY COURSE

Density and Specific gravity. (10 periods)

Review the meaning of the term density and show that density may be stated in various units, such as grams per cubic centimetre, grams per litre, pounds per cubic foot or cubic inch, pounds per gallon.

The meaning of the specific gravity (s.g.) of a substance.

An experiment to determine the density and the s.g. of a solid by measurement of its volume and by weighing it.

Experiments, involving the application of Archimedes' Principle, to determine the s.g. (1) of the brass cylinder used above, (2) of an irregular solid, denser than water, (3) of a liquid.

An experiment to demonstrate the principle of flotation.

The hydrometer — an experiment, using the hydrometer, to determine the s.g. of brine or other liquid.

Sound. (16 periods)

Experiments to show that sound has its origin in a vibrating source.

Experiments to illustrate vibratory motion using (a) the simple pendulum and (b) a spring with a weight attached.

The meaning of amplitude, period, and frequency as applied to vibratory motion.

The characteristics of sounds:

(1) Intensity; its dependence on the amplitude of vibration and the distance from the source (qualitative treatment only).

(2) Pitch; a demonstration of pitch using the Savart toothed wheel or the siren. The difference between tone and noise.

(3) Quality or timbre; a demonstration of differences in quality using tuning-fork, sonometer, organ pipe, etc.

An experiment to show that a material medium is necessary for the propagation of sound.

A quantitative experiment to show that the frequency of a stretched string varies inversely as the length.
A qualitative experiment to show that the frequency depends on the tension.

A discussion of wave motion, emphasizing that it is the transmission of vibration from particle to particle.
The transmission of energy by waves.
The interrelation of velocity, wave length and frequency.
An experiment to illustrate the propagation of transverse waves in any medium, e.g., in a rope or rubber tubing.

An experiment to show the way in which a stretched string vibrates — as a whole and in segments.
A discussion of the effect of the superposition of waves on the quality of the sound produced. Illustrate with two or more tuning-forks of different frequencies sounded together, or with one tuning-fork (a) bowed, (b) struck with a hard object, (c) bowed and struck so as to produce fundamental and overtone at the same time.

An experiment to illustrate the propagation of longitudinal waves in any medium, e.g., a brass coil.

A brief discussion of the reflection of sound and some of its applications.

A discussion of the measurement of the speed of sound by means of echoes or by a direct method.

Light.
— Transmission.
(4 periods)

An experiment to show that a material medium is not required.
Rectilinear propagation (review).
An experiment to show the production of a pinhole image and the change in size of this image with variation in the distance of the screen or of the source from the pinhole.
A discussion of the reason for the formation of the image.
Simple discussion of the velocity of light.

— Reflection.
(5 periods)

Experiments with plane mirror to derive the laws of reflection of light. Regular and diffuse reflection; discussion of direct and indirect lighting.
An experiment, using a single plane mirror, to show the location of images and the path of the rays to the eye.
Demonstrations, using a concave mirror, of (a) the focusing of parallel rays and (b) the production of a real image.

— Refraction.
(6 periods)

A demonstration of the refraction of light using (a) air and water and (b) air and glass. Explanation by means of waves.
An experiment to trace the path of light through a glass plate with parallel sides.

An experiment to show deviation produced by refraction through a prism.

Lenses.
(6 periods)

Kinds (1) convex (converging) (2) concave (diverging). Experiment to show the effect of (1) a convex lens (2) a concave lens on a beam of parallel rays. Principal focus and focal length. The path of a beam of parallel rays not parallel to principal axis, through a convex lens. Meaning of focal plane. Note that a ray through the centre of a lens is considered as passing straight through since the sides of the lens at this point are parallel. Optional: (1) Air lenses in water — convex and concave. These may be constructed by use of watch glasses and a waterproof cement. Water in a glass tank is clouded by castile soap. Glass lens under water has longer focal length. (2) Glass globe of water, in sunlight may cause a fire. (3) Sunlight recorder.

Experimental study of images formed by a convex lens. Note that as the object approaches the lens, (1) image recedes from the focal plane and becomes larger, (2) when object is at twice the focal length, image is at twice focal length and same size as the object. There should be no further memorizing of the nature and position of the images for various positions of the object.

All rays from each point on a distant object reach the lens as parallel rays, hence they focus on the focal plane. As the object approaches the lens, the rays from each point on it become divergent and hence are focused beyond the focal plane. When the object reaches the focal plane, the rays passed through the lens are parallel. When object is within the focal plane, rays are divergent and hence no real image, but a virtual image. The method of locating the image by diagram. In a concave lens the image formed is always virtual, smaller and erect.

Dispersion.
(3 periods)

Experiments to demonstrate the formation of spectrum of white light, and the combination of spectrum hues to form white light. The meaning of infra-red and ultra-violet.

Practical applications.
(6 periods)

The camera — lens, shutter, diaphram, bellows, film; why and how a camera is focused. The human eye; the function of its parts in the production of an image; recall iris reflex; the action of the lens in focusing the image (accommodation); comparison with the camera. (Technical terms are not required.) The most comfortable vision is when the object is at infinity; the most accurate vision is when the object is at about ten inches; strained vision is when the object is closer than ten inches. Converging lens used as a magnifier; the most comfortable vision is when the object is at the focal length of the lens; diagram of the ray paths.

The astronomical telescope illustrated by an experiment with two lenses of suitable focal lengths such as 50 cm. and 5 cm. Diagram of the ray paths.

Optional — use of an erecting lens.

Heat. — Heat transfer. (5 periods)	Review or teach the following: An experiment to show the comparative heat conductivities of different solids. Experiments to compare the radiation and absorption by dull dark, and light polished surfaces. The expansion of solids. An experiment to show the unequal expansion of metals. The thermostat.
— Heat measurements. (10 periods)	Calorimeter experiments to determine (1) the specific heat of a metal, (2) the heat of fusion of ice. A brief treatment of the heat of vaporization of water.
Electrostatics. (5 periods)	Experiments to show the electrification of ebonite rubbed with fur (or flannel) and of glass rubbed with silk (or chamois impregnated with tin amalgam). The charging of a pith ball by contact. Conductors and non-conductors. An experiment using the pith ball as an electroscope to show attraction and repulsion. An experiment to show that there are two kinds of electrification. The use of conventional terms — positive and negative — to classify electric charges. The construction and use of the goldleaf electroscope. Induced electric charges on an insulated metallic conductor; the charging of the conductor by induction; charging an electroscope by induction.
Magnetic effect of an electric current. (14 periods)	A review of elementary magnetism with a discussion of the use of lines to picture a magnetic field. An experiment to show magnetism induced in a paramagnetic substance placed near a bar magnet. A discussion of the difference between a temporary and a permanent magnet. Experiments to show (1) the lines of force about a wire carrying a current and the reversal of the magnetic field with a change in the direction of the current, (2) the magnetic field due to a current in a single turn of wire, (3) the magnetic field due to a current in a helix. The principle of a galvanometer with fixed coil and moving magnet (the galvanoscope). An experiment to show the increase in the strength of the magnetic field when an iron core is placed in a helix carrying a current. A study of several practical applications of the electromagnet such as the lifting magnet, electric bell, automobile generator cut-out. An experiment to demonstrate the motor principle, that is, to show the existence of a force acting on a wire carrying a current and lying in a magnetic field, the wire being at right angles to the direction of the lines of force.

The construction and action of a galvanometer with a fixed magnet and a moving coil. (The D'Arsonval galvanometer.) A discussion of the development of the moving coil galvanometer into an instrument for measuring current. (The ammeter.)

A study of the construction of a simple motor model as an application of the motor principle and as an example of the conversion of electrical energy into kinetic energy.

The chemical effects of an electric current. (8 periods)

Experiments to show the liberation of oxygen and hydrogen from water acidulated with sulphuric acid, and of copper from a copper sulphate solution, and to show that the amounts liberated are proportional to the strength or intensity (symbol I) of the current and to the time.
An experiment to show electroplating with copper and a discussion of electroplating with other metals.

An experiment to determine the strength or intensity of a current using the copper voltameter. Compare with the ammeter reading.
Definition of the ampere in terms of the weight of silver deposited in one second.
Definition of the coulomb as the quantity of electricity transferred when a current of one ampere flows for one second.

Explanation of a current in a wire as a flow of electrons and in a liquid as a flow of ions.
Reference to the convention that the direction of a current is that in which the positive electricity moves.

Primary and secondary cells. (6 periods)

The meaning of potential difference.
The meaning of the electromotive force (E.M.F.) of a cell.

An experiment with lead plates and dilute sulphuric acid to illustrate the principle of the storage cell.
The structure, action and care of the commercial lead storage battery. (Reference to energy transformations.)

The heat effect of an electric current. (2 periods)

A review of the transformation of electrical energy into heat energy and the subsequent radiation of energy.
A discussion of common electrical heating appliances.

Ohm's Law. (9 periods)

An experiment with dry cells, high resistance, and galvanometer to show that the intensity of a current is directly proportional to the potential difference (as indicated by the number of cells) causing it.

The principle of the common type of voltmeter.

An experiment to show that for any given conductor

$$\frac{\text{the P.D. between its ends}}{\text{current intensity}} \text{ is a constant.}$$

The definition of the resistance in ohms as the value of this constant when the P.D. is in volts and the current intensity in amperes.

Statement of Ohm's Law as $V = IR$. The legal definition of the ohm.
Simple problems.

The structure and use of the resistance box and the rheostat. Experiments to determine the resistance of a conductor by
(1) method of substitution,
(2) voltmeter-ammeter method.

Electromagnetic induction.
(15 periods)

The story of Faraday.

Experiments to show the cause of an induced current
(1) using a bar magnet, coil and galvanometer,
(2) using an electromagnet to replace the bar magnet,
(3) by the opening and closing of a primary circuit coupled with a secondary circuit.

Experiments to show the direction of the induced E.M.F. (Lenz's Law).

Experiments to show that the magnitude of an induced E.M.F. depends on (1) the strength of the changing magnetic field, (2) the number of turns of wire cut by the magnetic field, and (3) the rate at which the lines of force are cut.

An experiment with an earth inductor to show the production of alternating currents and the principle of the generator.

A discussion and demonstration of the use of a two-segment commutator to change alternating current (A.C.) into direct current (D.C.).

The transformer: the structure, action and use of a step-up and of a step-down transformer.

The telephone.

Self-inductance. An experiment to show self-induced E.M.F. when an inductive current is interrupted.

The induction coil: its structure, operation and use (details of the function of the condenser not required).

Conductivity of a gas.
(5 periods)

An experiment to show that a charged electroscope may be discharged by a lighted match or by a gas flame held near the knob of the electroscope.

An experiment with induction coil and either a set of simple Crookes' tubes at various pressures or a single tube capable of exhaustion by a pump, to show the conductivity of air at reduced pressure.

An experiment with a Crookes' tube containing a metal obstacle, to show that cathode rays (1) travel in straight lines, (2) excite fluorescence in the walls of the tube where they strike, and (3) are deflected by a magnet.

A simple discussion of the relation of cathode rays to electrons.

Explanation of the conductivity of a gas in terms of ions and electrons.

PHYSICS

OPTIONAL TOPICS

The obligatory courses can probably be taught in about three-quarters of the time available. The remainder of the time should be devoted to the study of topics selected from the optional portion of the course and to review. Teachers and pupils may have, therefore, the opportunity of spending additional time on topics in which they are particularly interested.

Musical scales.	The harmonic scale. A demostration of the major triad, major tetrad, and major diatonic scale by means of the sonometer with a string under constant tension, using successive lengths of 90 cm., 80 cm., 72 cm., 67.5 cm., 60 cm., 54 cm., 48 cm. (Similar proportions for any desired length may be used.) Recognition that the ratios of the vibration frequencies or successive notes in this scale comprise only three values, namely 9/8, 10/9, 16/15. Designation of these as major tone, minor tone, semitone so that the major diatonic scale is characterized by the succession, ma tone, mi tone s.t., ma.t., mi.t., ma.t., s.t. The equally tempered scale developed from this by making no distinction between major tone and minor tone, thus — tone, tone, semitone, tone, tone, tone semitone. Refer to piano keyboard.
Resonance.	Experiments to illustrate resonance: (1) using tuning forks or resonance bars of the same frequency (sympathetic vibrations), (2) using tuning fork and an air column whose length can be altered. The meaning of resonance with defining statement. A mechanical illustration of the principle of resonance. A brief discussion of the human voice with reference to the vocal cords and resonance.
Interference.	One or more experiments to illustrate interference, e.g. (1) silent points near a sounding tuning fork, (2) Herschel divided tube, (3) standing wave in a vibrating string (Melde's experiment), (4) the production of beats.
The ear.	A simple study of the ear to show how its parts function in the reception and transmission of vibrations. (Technical terms not required.)
Reflection.	An experiment to show the location of images and the path of the rays to the eye, using two plane mirrors at right angles.
Refraction.	An experiment to explain apparent depth in terms of refraction at a plane surface. A demonstration of total reflection; the use of a prism as a mirror. Experiments with a diverging lens as outlined for the converging lens.
Dispersion.	Complementary colours. An examination of the flame spectra of a few common elements such as sodium, calcium, and lithium and of the vacuum-tube spectra of such gases as neon, nitrogen, and hydrogen. The principle of identification of elements by their spectra. Experiments to show the effects of the transmission, reflection, and absorption of light in producing colours; colours of natural objects and of mixtures of pigments. A comparison of the effect of the combining of the colours of light with that obtained by mixing pigments.
Electrostatics.	An investigation of the effect of rubbing together various pairs of substances and a classification of the charges as positive or negative. Applications and illustrations; references to dangerous instances. An experiment to show (1) that both positive and negative charges are induced on an uncharged, insulated conductor when a charged body is brought near it, and (2) the charging of an insulated conductor by induction.

An experiment to show that a charge placed on an insulated hollow conductor goes to the outer surface.
A brief discussion of shielding with practical application, e.g. radio tubes.
An experiment to show the escape of a charge from a point. The lightning rod.

The meaning of potential difference.	Review the meaning of work, energy and power, with emphasis on gravitational potential energy.
	A demonstration with a positively charged pith ball (at the end of a short silk thread tied to a glass rod) between two charged insulated plates, one positive, the other negative, to show (1) the existence of a force acting on the pith ball anywhere in the region between the plates, (2) that the pith ball, if free to move, will go from the positive to the negative plate, and (3) that work must be done on the pith ball to move it from the negative to the positive plate.
	Explanation of the meaning of potential difference as a difference in potential energy and of the movement of charges, if free to move, whenever a potential difference exists. Reference to the volt as a practical unit of potential difference.
Measurement of electrical energy and electrical power.	Proof by the method given above that the energy gained when Q coulombs move in a wire under a potential difference of V volts is $V \times Q$ units and hence, that the electrical power is $V \times I$ units. Statement that 1 volt-ampere = 1 watt; 1 watt $= \frac{1}{746}$ horse power. The meaning of kilowatt-hour as a unit of energy. Simple problems relating to the cost of using electrical appliances.
X-rays.	An experiment with a small X-ray tube and an induction coil to show (1) the discharge of an electroscope by X-rays, and (2) the passage of X-rays through such substances as wood and paper. The origin of X-rays.
Thermionic emission of electrons.	An experiment with a diode tube (any radio tube may be used) to show that a current passes through the tube if (1) the filament is hot, and (2) the filament is negative with respect to the opposite electrode (Edison effect). Simple discussion of the liberation of electrons from a hot metal. Experiment, using A.C., to show the use of a radio tube in allowing current to flow in one direction only. The meaning of rectifier and rectification. Explanation of electrification in terms of electrons.
Photo-electricity.	An experiment to show that when light from an arc falls on a clean zinc plate connected to a negatively charged electroscope, the electroscope loses its charge. The meaning of photo-electricity; the structure and uses of a simple photo-electric cell.

GRADE 12

CHEMISTRY

Changes of state. (7 periods)	The three states of matter and their general characteristics. Melting and freezing, illustrated by water and naphthalene. Melting points as characteristic physical constants. Evaporation and condensation, illustrated by water or carbon tetrachloride. Boiling points as characteristic physical constants; influence of barometric pressure on boiling point. Sublimation, illustrated by iodine, benzoic acid or naphthalene. Effect of temperature on rate of evaporation of water. Effect of humidity. Changes in volume and energy accompanying changes of state. Explanation of changes of state in terms of the molecular theory of matter. (It should be stated that individually distinct molecular particles are not thought to exist under ordinary conditions for such substances as metals, salt, diamond, etc.). The use of characteristic physical properties (density, melting point, boiling point, ability to form solutions, etc.) for identification of substances.
Mechanical mixtures. (6 periods)	Study of such mechanical mixtures as iron and sulphur; copper filings and charcoal; clay and water; kerosene and water; sugar and sand. This should include a discussion of (i) properties of mixtures in relation to properties of the constituents, (ii) methods of separation. Study of naturally occurring mixtures, e.g., lake-shore sand, milk, tomato juice. Methods of separation of mixtures industrially; e.g. settling, filtering, centrifuging, froth flotation, magnetic separation, distillation.
Elements and compounds; Simple chemical reactions. (6 periods)	The distinction between physical and chemical change; a chemical change may be simply described as a process in which one or more new substances are produced. Study of (i) heating of mercuric oxide, (ii) heating of bluestone, (iii) electrolysis of water, as simple chemical changes. Law of conservation of mass applied to chemical changes. Simple experiments. Law of definite proportions. This should be illustrated by such experiments as (i) decomposition of mercuric oxide, (ii) combination of magnesium and oxygen, (iii) decomposition of bluestone to anhydrous copper sulphate and water vapour. The most important characteristic of a chemical substance is that it has a fixed composition. Elements and compounds. The experimental criterion of an element is that it is not composed of two or more other substances. Compounds are made from elements combined in definite proportions by weight. The properties of compounds are likely to differ from those of the constituent elements.
Oxygen. (8 periods)	Occurrence of the most abundant element in the free state and in compounds.

Laboratory preparation of oxygen by heating a mixture of potassium chlorate and manganese dioxide. Catalytic action of the manganese dioxide.
Industrial production by distillation of liquid air. Demonstration of the approximate percentage of oxygen by volume in air. Physical properties of oxygen.
The combustion in oxygen of charcoal, sulphur, phosphorus, magnesium, sodium, and iron. Properties of oxides of these, (state, colour, solubility in water, effect of solutions on litmus). This will require brief mention of acids and bases.
The combustion of compounds, for example, kerosene or alcohol, pyrite or sugar, showing the products formed. The combustion of foods.
Importance and uses of oxygen.
Meaning of terms combustion, exothermic, endothermic, kindling temperature, low-temperature oxidation, spontaneous combustion, heat of combustion, catalyst, oxidation.

Air and the production of nitrogen.
(4 periods)

The importance of air, its composition, (nitrogen, oxygen, rare gases, water vapour, carbon dioxide, dust particles). Processes tending to regulate the amount of carbon dioxide in the air.
The carbon cycle. Interdependence of plants and animals. Production of nitrogen from air. Physical properties, importance, and uses of nitrogen.

Reacting weights and atomic weights.
(8 periods)

The reacting weight of a substance (element or compound) is the number of parts by weight of that substance which reacts with 16 parts by weight of oxygen or with the reacting weight of some other substance. A substance may have several reacting weights; such weights are in the ratio of simple whole numbers.(Equivalent weights are defined in exactly the same terms as reacting weights but with reference to 8 parts by weight of oxygen). It should be stressed that the choice of 16 or 8 for oxygen is arbitrary. Law of Reacting Weights,— the weights of substances (elements or compounds) which take part in a chemical reaction are in the ratio of their reacting weights or multiples of them.
The atomic theory of John Dalton as an explanation of this law. The atomic weight of an element is a selected reacting weight and is based on the atomic weight of oxygen taken as 16. Atomic weights of the common elements may be introduced at this time.

Symbols, formulae and equations.
(10 periods)

The use of the symbol to denote the element and also to represent one atomic weight of the element.
The use of the formula to indicate the elements and their proportions in a compound, and also to indicate the molecular weight, where known, of the compound. For substances whose molecular weights have not been determined, the term formula weight is preferable.
Nomenclature of binary compounds.
Valence — an indication of the combining power of the atom of an element. The use of the chemical bond as a convenient method of illustrating valence. Simple structural formula

for hydrogen, chlorine, oxygen, nitrogen, hydrogen chloride, water, ammonia, methane, and carbon dioxide.
Chemical equations for simple reactions considered thus far.
Simple problems (i) to determine percentage composition from formulae, (ii) to determine formulae from percentage composition, (iii) to determine weights of reactants or products involved in these simple reactions.

Hydrogen.
(7 periods)

Preparation (i) by electrolysis of water, (ii) by action of water or steam on metals, (iii) by reaction of zinc and dilute sulphuric acid. Physical properties of hydrogen.
Burning of hydrogen in air and explosion with oxygen.
Uses of hydrogen.
Demonstration of the reaction between hydrogen and hot cupric oxide to illustrate the law of definite proportions and to find the composition of water (method of Dumas).

Water.
(6 periods)

Occurrence and distribution.
Natural water and preparation of pure water.
Properties of chemically pure water (density, boiling point, freezing point, etc.).
Production of a potable water supply.
Dehydration of copper sulphate pentahydrate (bluestone), and sodium carbonate decahydrate (washing soda). Water of hydration. Efflorescence. Anhydrous copper sulphate as test for the presence of water.
Hygroscopic materials; silica gel, concentrated sulphuric acid, glycerin, calcium chloride. Deliquescence of solids.

Solutions.
(6 periods)

Comparison of characteristics of solutions with those of mechanical mixtures.
Examples of solutions. These should be varied enough to show the existence of solutions in different physical states: e.g. air, including water vapour; low-melting alloys; gold and copper alloys; oil or grease in carbon tetrachloride; DDT in kerosene; carbonated beverages.
Meaning of terms: solvent, solute, solubility (relative and quantitative); saturated, unsaturated, and super-saturated solutions; solubility curve (to illustrate change of solubility with temperature). Factors which affect the rate of solution.

Acids and bases.
(8 periods)

Review the effect of acids on litmus.
Further properties of acids (dilute), (1) effect on indicators (2) action on carbonates, (3) action on suitable metals (magnesium), (4) taste as shown by soda-water, vinegar, sour milk, etc.
The effect of bases on the same indicators which were used for acids. The action upon litmus of the solutions of the oxides of the substances already burned in oxygen, and classification as acidic or basic oxides.
Testing a number of substances found in the household to classify them as having acidic or basic or neutral properties.
The reaction of an acid with a base to form a salt and water (neutralization).

Nomenclature of some oxy-acids and their salts, e.g. sulphates, sulphites, nitrates, carbonates, phosphates, chlorates, etc.; ammonium and hydroxide radicals.
Chemical equations and simple problems.

Determination of molecular weights. (12 periods)

The barometer and measurement of atmospheric pressure. Units of pressure: mm. or inches of mercury, atmospheres (one standard atmosphere = 760 mm. of mercury).
Boyle's law, experimentally demonstrated.
Charles' law, experimentally demonstrated. The Absolute Temperature scale.
Problems involving the above gas laws. Use of Standard Temperature and Pressure, (S.T.P.).
Reacting Volumes of gases, e.g. hydrogen and oxygen, demonstrated by the eudiometer. Gay-Lussac's law of combining gas volumes. Avogadro's principle as an explanation of the law of combining gas volumes, and as a proof of the existence of certain diatomic gas molecules, e.g. hydrogen and oxygen.
The diatomic oxygen molecule fixes the molecular weight of oxygen at 32. The volume of 32 grams of oxygen at S.T.P. is $32/1.429 = 22.4$ litres. By virtue of Avogadro's principle this volume of any other gas must contain the same number of molecules, and therefore a molecular weight of that gas. This is the experimental method of finding molecular weights for many substances. Use of the terms gram-molecular volume, gram-molecular weight or mole.
The use of molecular formulae for gases and vaporizable substances, and the information conveyed.
Problems involving (i) calculation of molecular weights with the aid of the gas laws, (ii) calculation of volumes of gases produced in chemical reactions.

Determination of Atomic weights. (4 periods)

Atomic weights are not obtained directly by experiment, but are chosen as the correct fraction or multiple of a reacting weight to correspond to an approximate atomic weight found (i) by application of the Dulong and Petit rule for specific heats, or (ii) Cannizzaro's method, which was to select the smallest weight of the element found in a gram-molecular weight of any compond of that element.

Note the relationship: $$\frac{\text{Atomic weight}}{\text{Equivalent weight}} = \text{Valence}$$

Carbon and its compounds. (7 periods)

Sources and properties of the different forms of carbon. Allotropism.
Uses of carbon in its various forms for lubrication, fuel, reduction, adsorption, etc.
The properties and uses of carbon dioxide reviewed.
The preparation of carbon dioxide by the action of acids on carbonates and a detailed study of its properties.
The action of baking soda in a baking powder. The effect of pressure on the solubility of carbon dioxide in water (Henry's Law).
The action of heat on carbonates.

The sources of carbon monoxide; dangerous and useful properties. The preparation, properties and uses of acetylene. Presence of carbon in fats, carbohydrates, and proteins.

Fuels.
(6 periods)

General survey of solid, liquid, and gaseous fuels.
Heat of combustion — a transformation of chemical potential energy to heat energy.
A comparison of the calorific value of various fuels.
Atomic Energy — comparison with molecular energy.
Discussion of its potentialities and Canada's position as a supplier of fissionable material. The destructive distillation of coal, reference to the important products obtained. A demonstration of fractional distillation; reference to its application in the refining of petroleum.

Sulphur and its compounds.
(8 periods)

Sources of sulphur.
The preparation of the allotropes (rhombic, monoclinic, plastic).
Properties and uses of sulphur.
Demonstration of the preparation of hydrogen sulphide and its uses in the preparation of metallic sulphides.
(Note the tendency of some of these sulphides, such as arsenic, antimony and zinc, to pass through filter paper.)
The laboratory preparation of sulphur dioxide. The properties of its solution and its uses, e.g. bleaching and the production of sulphites (chemical wood pulp).
The principles of the commercial production of sulphuric acid.
The properties and uses of sulphuric acid.
References to such sulphates as those of calcium, copper, magnesium, and sodium.

Common salt.
(4 periods)

A brief discussion of the commercial recovery and industrial importance of salt.
A study of its properties.
A study of the reaction of sulphuric acid with salt.
The laboratory preparation and properties of hydrogen chloride and of hydrochloric acid.

Sodium and potassium.
(3 periods)

The action of air on sodium and on potassium. A review of the reaction of these metals with water.
A discussion of the properties of metals as illustrated by sodium and potassium.
A comparison of the properties of sodium hydroxide and potassium hydroxide.
The flame test for the presence of sodium and potassium.

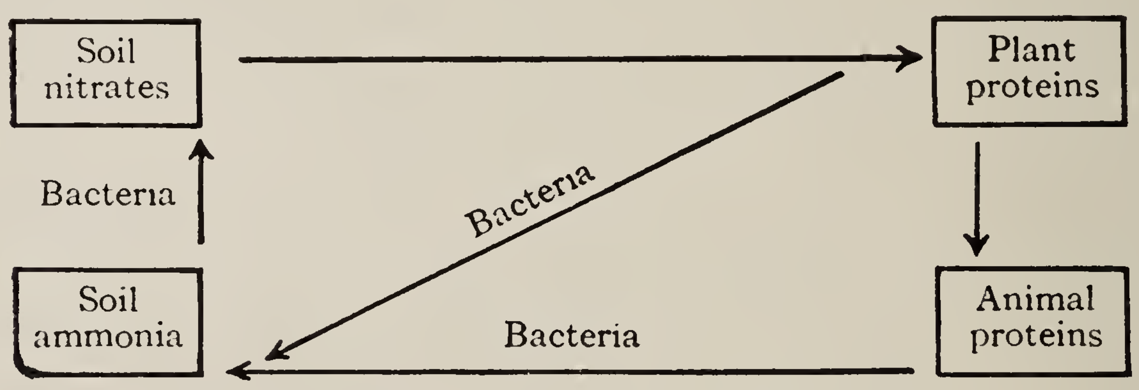
Halogens.
(9 periods)

A discussion of the production of chlorine by the electrolysis of salt.
Experiments to prepare chlorine in test-tubes by the oxidation of hydrogen chloride (as hydrochloric acid).
A demonstration of the preparation and collection of chlorine and a detailed study of its properties.
An experimental study of the properties of an aqueous solution of chlorine.

A demonstration of the preparation and collection of bromine and an experimental study of its properties.
A demonstration of the relative activity of chlorine and of bromine vapour by comparison of the reactions with antimony, moist blue litmus paper, and solutions of sodium chloride, sodium bromide and sodium iodide.
Commercial sources and uses of bromine.
A demonstration of the preparation and collection of iodine.
A comparison of the properties of chlorine, bromine, and iodine. Reference to fluorine — its importance in dental health.

Compounds of nitrogen.
(7 periods)

The properties of nitrogen.
Laboratory preparation of nitric acid; its acid properties when diluted; its oxidizing action when concentrated; its uses; its toxic effect.
The properties and uses of such nitrates as those of sodium, potassium, ammonium, and calcium.
The brown-ring test for nitrates.
Laboratory preparation of ammonia; its properties and uses.
Properties of a solution of ammonia.
Brief discussion of the formation and properties of such ammonium salts as ammonium chloride and ammonium sulphate.
Nitrogen and soil fertility — simple explanation of the nitrogen cycle.



Inert gases.
(2 periods)

The presence of rare gases in the air.
Discuss their chemical inactivity and commercial uses.
Commercial source of helium. Briefly discuss the history of the discovery of these gases, emphasizing the importance of precise and painstaking research.

Calcium and magnesium.
(6 periods)

The reaction of calcium with water.
Occurrence of calcium carbonate (limestone and marble).
Heating of calcium carbonate. The commercial preparation of quicklime. The slaking of quicklime.
Commercial uses of limestone, quicklime, slaked lime, gypsum, bleaching powder, calcium chloride.
Occurrence of magnesium in dolomite. Reference to Canadian production in Renfrew county (Pidgeon Process).
Properties of magnesium.
It should be emphasized that the metal is resistant to oxidation at ordinary temperatures; only the ribbon or wire forms

of magnesium are readily ignited. Importance of magnesium in making low-density alloys such as magnalium.

Rate of reaction. (3 periods)

Throughout the course the attention of students should be directed to instances of the following factors influencing the rates of reactions:
(1) heat (2) light (3) concentration (4) surface area (5) catalysis. At the conclusion of the course a recapitulation of this topic should be made.

Industrial chemistry.

A class which is situated near an industry which uses chemical processes should make a study of those processes whenever practicable, in order to make students realize that chemical reactions are the basis of many of our industries.

AGRICULTURAL SCIENCE

In schools where the Science courses in Grades 9 and 10 have included agricultural topics, the Board may introduce Agricultural Science in Grades 11 and 12, provided the approval of the Minister is obtained prior to the beginning of the school year.

These courses include the essential topics of the courses in Physics and Chemistry and a number of agricultural topics, the study of which will enlarge and extend the work begun in Grades 9 and 10. The obligatory agricultural topics as outlined should be taught in the regular school programme. As far as possible, individual interest and initiative should be encouraged and the instruction in laboratory and classroom correlated with practical activities outside of school. Display of special equipment, illustrative charts and other material related to Agriculture should be arranged in the laboratory. School experimental plots, home projects and agricultural reading are optional topics which should be taken under the conditions suggested in the syllabus.

The science topics of Grades 11 and 12 should be treated experimentally and emphasis placed on pupil experiments throughout the course. Accuracy and precision in making observations, taking measurements and reaching conclusions are the main desiderata. Encouragement should be given to the recording of experiments by means of simple line diagrams, supplemented by very brief notes. Time should not be wasted in writing notes from dictation or in copying material from text or manual. The pupils' note-books should, however, contain a systematic record of the work covered.

GRADE 11

AGRICULTURAL SCIENCE, PART I

NOTE. — Topics marked with an asterisk (*) are optional.

Botany.
(8 periods)

Parasitic fungi; the examination and recognition in different stages and methods of control of stem rust of wheat, loose smut of oats, late blight of potatoes, brown rot of stone fruits, any mildew (cherry, lilac, grape), also the effect of these diseases on the grading and market value of farm products.

Entomology.
(8 periods)

Life history and nature of injury and methods of control of white grub or wire worm, plum curculio or potato beetle, oyster shell scale or aphides, tent caterpillar or European corn borer, warble fly or bot fly.
The effect of insect injuries on the market value of farm products.
Reference to the spray calendar and spray service.

Density and specific gravity.
(10 periods)

Review the meaning of the term density, and show that density may be stated in various units, such as grams per cubic centimetre, grams per litre, pounds per cubic foot or cubic inch, pounds per gallon.
The meaning of the specific gravity (s.g.) of a substance.
An experiment to determine the density and the s.g. of a solid by measurement of its volume and by weighing it.
Experiments involving the application of Archimedes' Prin-

ciple, to determine the s.g. (1) of the brass cylinder used above; (2) of an irregular solid, denser than water; (3) of a liquid.
An experiment to demonstrate the principle of flotation.
The hydrometer; an experiment, using the hydrometer, to determine the s.g. of brine or other liquid; or using the lactometer to determine the specific gravity of milk.

Mechanics.
(5 periods)

Review of levers and pulleys. Applications in farm machinery and appliances.

Light.
— Transmission.
(4 periods)

An experiment to show that a material medium is not required.
Rectilinear propagation (review).
An experiment to show the production of a pinhole image and the change in size of this image with variation in the distance of the screen or of the source of light from the pinhole. A discussion of the reason for the formation of the image.
Simple discussion of the velocity of light.

— Reflection.
(5 periods)

Experiments with plane mirror to derive the laws of reflection of light. Regular and diffuse reflection; discussion of direct and indirect lighting.
An experiment, using a single plane mirror, to show the location of images and the path of the rays to the eye.
Demonstrations, using a concave mirror, of (a) the focusing of parallel rays and (b) the production of a real image.

— Refraction.
(6 periods)

A demonstration of the refraction of light using (a) air and water and (b) air and glass. Explanation by means of waves.
An experiment to trace the path of light through a glass plate with parallel sides.
An experiment to show deviation through a prism.

Lenses.
(6 periods)

Kinds (1) convex (converging) (2) concave (diverging). Experiment to show the effect of (1) a convex lens (2) a concave lens on a beam of parallel rays. Principal focus and focal length. The path of a beam of parallel rays not parallel to principal axis, through a convex lens. Meaning of focal plane. Note that a ray through the centre of a lens is considered as passing straight through since the sides of the lens at this point are parallel.

Optional: (1) Air lenses in water — convex and concave. These may be constructed by use of watch glasses and a waterproof cement. Water in a glass tank is clouded by castile soap. Glass lens under water has longer focal length.
(2) Glass globe of water, in sunlight may cause a fire.
(3) Sunlight recorder.

Experimental study of images formed by a convex lens. Note that as the object approaches the lens, (1) image recedes from the focal plane and becomes larger, (2) when object is at twice the focal length, image is at twice focal length and same size as the object. There should be no

further memorizing of the nature and position of the images for various positions of the object. All rays from each point on a distant object reach the lens as parallel rays, hence they focus on the focal plane. As the object approaches the lens, the rays from each point on it become divergent and hence are focused beyond the focal plane. When the object reaches the focal plane, the rays are divergent and hence no real image, but a virtual image. The method of locating the image by diagram. In a concave lens the image formed is always virtual, smaller and erect.

Dispersion.
(3 periods)

Experiments to demonstrate the formation of the spectrum of white light, and the combination of the spectrum hues to form white light. The meaning of infra-red and ultra-violet.

Practical applications.
(6 periods)

The camera — lens, shutter, diaphragm, bellows, film; why and how a camera is focused. The human eye; the function of its parts in the production of an image; recall iris reflex; the action of the lens in focusing the image (accommodation); comparison with the camera. (Technical terms are not required.) The most comfortable vision is when the object is at infinity; the most accurate vision is when the object is at about ten inches; strained vision is when the object is closer than ten inches. Converging lens used as a magnifier, the most comfortable vision is when the object is at the focal length of the lens; diagram of the ray paths.

The astronomical telescope illustrated by an experiment with two lenses of suitable focal lengths such as 50 cm. and 5 cm. Diagram of the ray paths. Optional — the use of an erecting lens.

Heat.
— Heat transfer.
(5 periods)

Review or teach the following.

An experiment to show the comparative heat conductivities of different solids.
Experiments to compare the radiation and absorption by dull dark, and light polished surfaces.

The expansion of solids. An experiment to show the unequal expansion of metals. The thermostat as illustrated in the incubator.

— Heat measurements.
(10 periods)

Calorimeter experiments to determine (1) the specific heat of a metal, (2) the heat of fusion of ice. A brief treatment of heat vapourization of water.

Landscaping.
(5 periods)

Recall making and care of a lawn; a suitable lawn seed mixture.
Formal and natural landscaping plans. The location of walks or paths, the use of curves and open spaces, relation of plantings of different heights.
Planting material; annual, biennial and perennial flowering plants, and shrubs suitable for different locations and for the best seasonal display. Planting plans for home and school gardens.

Sound.
(10 periods)

Experiments to show that sound has its origin in a vibrating source.
The meaning of amplitude, period, and frequency as applied to vibratory motion.
The characteristics of sounds:
(1) Intensity; its dependence on the amplitude of vibration and the distance from the source (qualitative treatment only).
(2) Pitch; a demonstration of pitch using the Savart toothed wheel or the siren. The difference between tone and noise.
(3) Quality or timbre; a demonstration of differences in quality using tuning-fork, sonometer, organ pipe, etc.
An experiment to show that a material medium is necessary for the propagation of sound.
A quantitative experiment to show that the frequency of a stretched string varies inversely as the length.
A qualitative experiment to show that the frequency depends on the tension.
The interrelation of velocity, wave length and frequency.
A brief discussion of the reflection of sound and some of its applications.
A discussion of the measurements of the speed of sound by means of echoes or by direct methods.

*Home projects.

Under the supervision of the teacher, suitable home projects, preferably of an economic value, should be undertaken by selected pupils in Grades 11 and 12. In many cases, such projects may be associated with the local Junior Club programme.
The following suggested projects are suitable for this type of treatment:
(1) Home grounds beautification.
(2) The improvement of the poultry flock by introduction of egg-laying strains and keeping of records.
(3) Improvement of the dairy herd by (1) starting with a pure-bred calf or (2) by keeping records and selection.
(4) The building up of an apiary.
(5) Permanent pasture improvement.
(6) Improvement of crops by plant and seed selection.
(7) Growing of plots of recommended varieties of potatoes, pasture grasses, or grains from certified seed.
(8) Soil improvement by crop rotation and fertilizer treatment over a period of years.
(9) In fruit-growing areas, the introduction of approved varieties by grafting and planting.

*Gardening.

Elementary gardening practice in planting and care of vegetables and flowers has been covered in Grades 9 and 10.
Gardening activities **if continued in the Senior Division** should be taken with Grade 11 pupils, and must be of a definite practical nature such as a school-ground improvement programme, planting and care of beds of perennial

* Co-operation with local Horticultural Society in pupils' projects.

flowers or shrubs, the making of a lawn or the conducting of experimental plots with varieties of grasses, grains, potatoes or other crops with or without fertilizers on plots 1/100 of an acre or 436 sq. feet in area. Garden plots should contain at least four such areas.

*Agricultural reading.

In the average class, and particularly in the smaller schools, there are a number of boys who come from farm homes and who, after leaving school, are likely to engage in farming. These pupils may have developed an interest in certain agricultural topics and would benefit from more information on the subject than has been offered in the classroom study. The teacher should try to assist such pupils by providing a suitable list of references for reading and study from books, bulletins and magazines which are in the library. In the case of pupils who are not taking all subjects in Grades 11 and 12, at least part of the free periods should be given to such reading and study.

Electrostatics. (8 periods)

Experiments to show the electrification of ebonite rubbed with fur (or flannel) and of glass rubbed with silk (or chamois impregnated with tin amalgam).
The charging of a pith ball by contact. Conductors and non-conductors.
An experiment using the pith ball as an electroscope to show attraction and repulsion. An experiment to show that there are two kinds of electrification.
The use of conventional terms; positive and negative — to classify electric charges.
The construction and use of the goldleaf electroscope.
An experiment to show the escape of a charge from a point. The lightning rod.
Induced electric charges on an insulated metallic conductor; the charging of the conductor by induction; charging an electroscope by induction.

Magnetic effect of an electric current. (14 periods)

A review of elementary magnetism with a discussion of the use of lines to picture a magnetic field.
An experiment to show magnetism induced in a paramagnetic substance placed near a bar magnet.
A discussion of the difference between a temporary and a permanent magnet.

Experiments to show (1) the lines of force about a wire carrying a current and the reversal of the magnetic field with a change in the direction of the current, (2) the magnetic field due to a current in a single turn of wire, (3) the magnetic field due to a current in a helix. The principle of a galvanometer with fixed coil and moving magnet (the galvanoscope).
An experiment to show the increase in the strength of the magnetic field when an iron core is placed in a helix carrying a current.
A study of several practical applications of the electromagnet such as lifting magnet, electric bell, automobile generator cut-out.

An experiment to demonstrate the motor principle, that is, to show the existence of a force acting on a wire carrying a current and lying in a magnetic field, the wire being at right angles to the direction of the lines of force.

The construction and action of a galvanometer with a fixed magnet and a moving coil. (The D'Arsonval galvanometer.) A discussion of the development of the moving coil galvanometer into an instrument for measuring current (the ammeter).

A study of the construction of a simple motor model as an application of the motor principle and as an example of the conversion of electrical energy into kinetic energy.

The chemical effects of an electric current.
(8 periods)

Experiments to show the liberation of oxygen and hydrogen from water acidulated with sulphuric acid, and of copper from a copper sulphate solution, and to show that the amounts liberated are proportional to the strength or intensity (symbol I) of the current and to the time.
An experiment to show electroplating with copper and a discussion of electroplating with other metals.
An experiment to determine the strength or intensity of a current using the copper voltameter. Compare with the ammeter reading.
Definition of the ampere in terms of the weight of silver deposited in one second.
Definition of the coulomb as the quantity of electricity transferred when a current of one ampere flows for one second.
Explanation of a current in a wire as a flow of electrons and in a liquid as a flow of ions.
Reference to the convention that the direction of a current is that in which the positive electricity moves.

Primary and secondary cells.
(6 periods)

The meaning of potential difference.
The meaning of the electromotive force (E.M.F.) of a cell.
An experiment with lead plates and dilute sulphuric acid to illustrate the principle of the storage cell.
The structure, action and care of the commercial lead storage battery. (Reference to energy transformations.)

The heat effect of an electric current.
(2 periods)

A review of the transformation of electrical energy into heat energy and the subsequent radiation of energy.
A discussion of common electrical heating appliances.

Ohm's Law.
(2 periods)

An experiment with dry cells, high resistance, and galvanometer to show that the intensity of a current is directly proportional to the potential difference (as indicated by the number of cells) causing it. Statement and explanation of Ohm's Law. $V = IR$. Definition of the ohm.
The principle of the common type of voltmeter.

Electromagnetic induction.
(15 periods)

The story of Faraday.

Experiments to show the cause of an induced current
(1) using a bar magnet, coil and galvanometer,

(2) using an electromagnet to replace the bar magnet,
(3) by the opening and closing of a primary circuit coupled with a secondary circuit.

Experiments to show the direction of the induced E.M.F. (Lenz's Law).
Experiments to show that the magnitude of an induced E.M.F. depends on (1) the strength of the changing magnetic field, (2) the number of turns of wire cut by the magnetic field, and (3) the rate at which the lines of force are cut.
An experiment with an earth inductor to show the production of alternating currents and the principle of the generator.

A discussion and demonstration of the use of a two-segment commutator to change alternating current (A.C.) into direct current (D.C.).

The transformer: the structure, action and use of a step-up and of a step-down transformer.

The telephone.

Self-inductance. An experiment to show self-induced E.M.F. when an inductive current is interrupted.

The induction coil: its structure, operation and use (details of the function of the condenser not required).

Conductivity of a gas. (5 periods)

An experiment to show that a charged electroscope may be discharged by a lighted match or by a gas flame held near the knob of the electroscope.

An experiment with induction coil and either a set of simple Crookes' tubes at various pressures or a single tube capable of exhaustion by a pump, to show the conductivity of air at reduced pressure.

An experiment with a Crookes' tube containing a metal obstacle, to show that cathode rays (1) travel in straight lines, (2) excite fluorescence in the walls of the tube where they strike, and (3) are deflected by a magnet.

A simple discussion of the relation of cathode rays to electrons.
Explanation of the conductivity of a gas in terms of ions and electrons.

Field crops. (8 periods)

Kinds of crops, common types of farming, with special reference to the distribution and economic value of crops in the local area.
Crop distribution in Ontario.

A discussion of the meaning of crop rotation with examples from farms in the local area; importance and value; surveys of crop rotations.

Examination of a sample of grain to show the value of cleaning seed. The importance of pure seed in relation to weed control.
Germination tests.

Use of bulletins and literature in the discussion of new varieties (sources of information and their use).

Live Stock.
(8 periods)

Review of principle types and breeds of cattle, draught horses, swine and sheep, with emphasis on the distinguishing characteristics and importance of each.
Chief market cuts of meat; grades of meat.

* Visits to local farms to study methods of stabling and care of cattle.

OR

Fruit growing.
(8 periods)

Orchard management: planning and planting the orchard; pruning, grafting, spraying, cultivating, fertilizing; use of cover crops.
Harvesting, packing and marketing; grading and types of packing for two different kinds of fruits of the locality; cold storage and natural storage.
Planting, care and marketing of strawberries and raspberries; varieties grown locally.

* Visits to fruit farms and packing houses to study methods employed there.

OR

Floriculture.
(8 periods)
(suggested for urban schools)

A. Trees and shrubs — deciduous, evergreen. Selection, planting, seasonal care, propagation.

B. Perennials — soil preparation, fertilizing, varieties, propagation; the perennial border.

C. Annuals and Biennials — sowing, transplanting, summer care.

Discuss in detail the culture of a number of our popular annual, biennial, and perennial flowers including bulbs and tuberous rooted plants.
Visit a greenhouse and study methods used. Maintain school flower beds.

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* Optional

GRADE 12

AGRICULTURAL SCIENCE, PART II

Change of State.
(7 periods)

The three states of matter and their general characteristics. Melting and freezing, illustrated by water and naphthalene. Melting points as characteristic physical constants.

Evaporation and condensation, illustrated by water or carbon tetrachloride.

Boiling points as characteristic physical constants; influence of barometric pressure on boiling point.

Sublimation, illustrated by iodine, benzoic acid or naphthalene. Effect of temperature on rate of evaporation of water. Effect of humidity.

Changes in volume and energy accompanying changes of state. Explanation of changes of state in terms of the molecular theory of matter.

(It should be stated that individually distinct molecular particles are not thought to exist under ordinary conditions for such substances as metals, salt, diamond, etc.).

The use of characteristic physical properties (density, melting point, boiling point, ability to form solutions, etc.) for identification of substances.

Mechanical mixtures.
(6 periods)

Study of such mechanical mixtures as iron and sulphur; copper filings and charcoal; clay and water; kerosene and water; sugar and sand. This should include a discussion of (i) properties of mixtures in relation to properties of the constituents, (ii) methods of separation.

Study of naturally occurring mixtures, e.g. lake-shore sand, milk, tomato juice.

Methods of separation of mixtures industrially; e.g., settling, filtering, centrifuging, froth flotation, magnetic separation, distillation.

Elements and compounds; Simple chemical reactions.
(6 periods)

The distinction between physical and chemical change; a chemical change may be simply described as a process in which one or more new substances are produced.

Study of (i) heating of mercuric oxide, (ii) heating of bluestone, (iii) electrolysis of water, as simple chemical changes.

Law of conversion of mass applied to chemical changes. Simple experiments.

Law of definite proportions. This should be illustrated by such experiments as (i) decomposition of mercuric oxide, (ii) combination of magnesium and oxygen, (iii) decomposition of bluestone to anhydrous copper sulphate and water vapour.

The most important characteristic of a chemical substance is that it has a fixed composition.

Elements and compounds. The experimental criterion of an element is that it is not composed of two or more other

substances. Compounds are made from elements combined in definite proportions by weight. The properties of compounds are likely to differ from those of the constituent elements.

Oxygen.
(8 periods)

Occurrence of the most abundant element in the free state and in compounds.

Laboratory preparation of oxygen by heating a mixture of potassium chlorate and manganese dioxide. Catalytic action of the manganese dioxide.

Industrial production by distillation of liquid air. Demonstration of the approximate percentage of oxygen by volume in air. Physical properties of oxygen.

The combustion in oxygen of charcoal, sulphur, phosphorus, magnesium, sodium, and iron. Properties of oxides of these (state, colour, solubility in water, effect of solutions on litmus). This will require brief mention of acids and bases. The combustion of compounds, for example, kerosene or alcohol, pyrite or sugar, showing the products formed. The combustion of foods.

Importance and uses of oxygen.

Meaning of terms exothermic, endothermic, kindling temperature, low-temperature oxidation, spontaneous combustion, heat of combustion, catalyst, oxidation, combustion.

Air and the production of nitrogen.
(4 periods)

The importance of air, its composition, (nitrogen, oxygen, rare gases, water vapour, carbon dioxide, dust particles.) Processes tending to regulate the amount of carbon dioxide in the air.

The carbon cycle. Interdependence of plants and animals. Production of nitrogen from air. Physical properties, importance, and uses of nitrogen. Legume bacteria absorb nitrogen from the air.

Reacting weights and atomic weights.
(8 periods)

The reacting weight of a substance (element or compound) is the number of parts by weight of that substance which reacts with 16 parts by weight of oxygen or with the reacting weight of some other substance. A substance may have several reacting weights; such weights are in the ratio of simple whole numbers. (Equivalent weights are defined in exactly the same terms as reacting weights but with reference to 8 parts by weight of oxygen.)

It should be stressed that the choice of 16 or 8 for oxygen is arbitrary.

Law of Reacting Weights — the weights of substances (elements or compounds) which take part in a chemical reaction are in the ratio of their reacting weights or multiples of them.

The atomic theory of John Dalton as an explanation of this law. The atomic weight of an element is a selected reacting

weight and is based on the atomic weight of oxygen taken as 16. Atomic weights of the common elements may be introduced at this time.

Symbols, formulae and equations. (10 periods)

The use of the symbol to denote the element and also to represent one atomic weight of the element.

The use of the formula to indicate the elements and their proportions in a compound, and also to indicate the molecular weight, where known, of the compound. For substances whose molecular weights have not been determined, the term formula weight is preferable.

Nomenclature of binary compounds.

Valence — an indication of the combining power of the atom of an element. The use of the chemical bond as a convenient method of illustrating valence. Simple structural formulae for hydrogen, chlorine, oxygen, nitrogen, hydrogen chloride, water, ammonia, methane, carbon dioxide.

Chemical equations for simple reactions considered thus far.

Simple problems (i) to determine percentage composition from formulae, (ii) to determine formulae from percentage composition, (iii) to determine weights of reactants or products involved in these simple reactions.

Hydrogen. (5 periods)

Preparation (i) by electrolysis of water, (ii) by action of water or steam on metals, (iii) by reaction of zinc and dilute sulphuric acid. Physical properties of hydrogen. Burning of hydrogen in air and explosion with oxygen.

Uses of hydrogen.

Demonstration of the reaction between hydrogen and hot cupric oxide to illustrate the law of definite proportions and to find the composition of water (method of Dumas).

Water. (4 periods)

Occurrence and distribution.

Natural water and preparation of pure water.

Properties of chemically pure water (density, boiling point, freezing point, etc.).

Production of potable water supply.

Dehydration of copper sulphate pentahydrate (bluestone), and sodium carbonate decahydrate (washing soda). Water of hydration. Efflorescence. Anhydrous copper sulphate as test for the presence of water.

Hygroscopic materials; silica gel, concentrated sulphuric acid, glycerin, calcium chloride. Deliquescence of solids.

Solutions. (4 periods)

Comparison of characteristics of solutions with those of mechanical mixtures.

Examples of solutions. These should be varied enough to show the existence of solutions in different physical states: e.g., air, including water vapour; low-melting alloys; gold and copper alloys; oil or grease in carbon tetrachloride; DDT in kerosene; carbonated beverages.

Meanings of terms: solvent, solute, solubility (relative and quantitative); saturated, unsaturated, and super-saturated solutions; solubility curve (to illustrate change of solubility with temperature.) Factors which affect the rate of solution.

Acids and bases.
(3 periods)

Review the effect of acids on litmus.

Further properties of acids (dilute), (1) effect on indicators, (2) action on carbonates, (3) action on suitable metals (magnesium), (4) taste as shown by soda-water, vinegar, sour milk, etc.

The effect of bases on the same indicators which were used for acids. The action upon litmus of the solutions of the oxides in the substances already burned in oxygen and classification as acidic or basic oxides.

Testing a number of substances found in the household to classify them as having acidic or basic or neutral properties. The reaction of an acid with a base to form a salt and water (neutralization).

Nomenclature of some oxy-acids and their salts, e.g., sulphates, sulphites, nitrates, carbonates, phosphates, chlorates, etc.; ammonium and hydroxide radicals.

Chemical equations and simple problems.

Determination of molecular weights.
(12 periods)

The barometer and measurement of atmospheric pressure. Units of pressure: mm. or inches of mercury, atmospheres (one standard atmosphere = 760 mm. of mercury).

Boyle's law, experimentally demonstrated.

Charles' law, experimentally demonstrated. The Absolute Temperature scale.

Problems involving the above gas laws. Use of Standard Temperature and Pressure, (S.T.P.).

Reacting Volumes of gases, e.g., hydrogen and oxygen, demonstrated by the eudiometer. Gay-Lussac's law of combining gas volumes. Avogadro's principle as an explanation of the law of combining gas volumes, and a proof of the existence of certain diatomic gas molecules, e.g., hydrogen and oxygen.

The diatomic oxygen molecule fixes the molecular weight of oxygen at 32. The volume of 32 grams of oxygen at S.T.P. is $32/1.429 = 22.4$ litres. By virtue of Avogadro's principle this volume of any other gas must contain the same number of molecules, and therefore a molecular weight of that gas. This is the experimental method of finding

molecular weights for many substances. Use of the terms gram-molecular volume, gram-molecular weight or mole.

The use of molecular formulae for gases and vaporizable substances, and the information conveyed.

Problems involving (i) calculation of molecular weights with the aid of the gas laws, (ii) calculation of volumes of gases produced in chemical reactions.

Determination of atomic weights. (4 periods)

Atomic weights are not obtained directly be experiment, but are chosen as the correct fraction or multiple of a reacting weight to correspond to an approximate atomic weight found (i) by application of the Dulong and Petit rule for specific heats, or (ii) Cannizzaro's method, which was to select the smallest weight of the element found in a gram-molecular weight of any compound of that element.

Note the relationship: $\dfrac{\text{Atomic weight}}{\text{Equivalent weight}} = \text{Valence}$

Carbon and its compounds. (7 periods)

Sources and properties of the different forms of carbon.

Allotropism.

Uses of carbon in its various forms for lubrication, fuel, reduction, adsorption, etc.

The properties and uses of carbon dioxide, reviewed.

The preparation of carbon dioxide by the action of acids on carbonates and a detailed study of its properties.

The action of baking soda in a baking powder. The effect of pressure on the solubility of carbon dioxide in water (Henry's Law).

The action of heat on carbonates.

The sources of carbon monoxide; dangerous and useful properties.

The preparation, properties and uses of acetylene.

Presence of carbon in fats, carbohydrates, and proteins.

Fuels. (4 periods)

General survey of solid, liquid, and gaseous fuels.

Heat of combustion — a transformation of chemical potential energy to heat energy.

A comparison of the calorific value of various fuels.

Atomic Energy — comparison with molecular energy.

Discussion of its potentialities and Canada's position as a supplier of fissionable material. The destructive distillation of coal, reference to the important products obtained. A demonstration of fractional distillation; reference to its application in the refining of petroleum.

Poultry. (8 periods)

The structure of the egg, candling and weighing. Grades of eggs; food value of eggs; culling poultry for egg production. The meaning of the term "dressed" fowl; methods of finishing, killing and plucking; marketing eggs and dressed poultry. Grades of poultry.

Examination of eggs broken open every one or two days during incubation to observe the stages in the development of the embryo.

Dairying. (8 periods)

The principle of the Babcock test; the use of this test in determining the percentage of fat in cream.

Washing, sterilization and care of dairy utensils. Care of milk and cream on the farm. Making butter with a laboratory churn.

Experiment to determine the percentage of water in a sample of butter; sale of butter by grade.

Distribution and importance of the dairy industry in Ontario; commercial milk products and their importance.

Sulphur and its compounds. (6 periods)

Sources of sulphur.

The preparation of the allotropes (rhombic, monoclinic, plastic). Properties and uses of sulphur.

Demonstration of the preparation of hydrogen sulphide and its use in the preparation of metallic sulphides. (Note the tendency of some of these sulphides, such as arsenic, antimony and zinc, to pass through filter paper.)

The laboratory preparation of sulphur dioxide. The properties of its solution and its uses, e.g., bleaching and the production of sulphites (chemical wood pulp).

The principles of the commercial production of sulphuric acid.

The properties and uses of sulphuric acid.

References to such sulphates as those of calcium, copper, magnesium, and sodium.

Common salt. (4 periods)

A brief discussion of the commercial recovery and industrial importance of salt.

A study of its properties.

A study of the reaction of sulphuric acid with salt.

The laboratory preparation and properties of hydrogen chloride and of hydrochloric acid.

Sodium and potassium. (3 periods)

The action of air on sodium and on potassium. A review of the reaction of these metals with water.

A discussion of the properties of metals as illustrated by sodium and potassium.

A comparison of the properties of sodium hydroxide and potassium hydroxide.

The flame test for the presence of sodium and potassium. Test for potassium in soils.

Phosphorus. (4 periods)

Reference to yellow and red forms, phosphorus pentoxide and phosphoric acid; meaning of the term "phosphoric acid" as applied to soils and fertilizers. Forms of calcium phosphate and their relative solubility; compounds which supply phosphorus. Test for phosphates in soils.

Halogens. (7 periods)

A discussion of the production of chlorine by the electrolysis of salt.

Experiments to prepare chlorine in test tubes by the oxidation of hydrogen chloride (as hydrochloric acid).

A demonstration of the preparation and collection of chlorine and a detailed study of its properties. An experimental study of the properties of an aqueous solution of chlorine.

An experimental study of the properties of bromine.

A demonstration of the relative activity of chlorine and of bromine vapour by comparison of the reactions with antimony, moist blue litmus paper, and solutions of sodium chloride, sodium bromide and sodium iodide.

Commercial sources and uses of bromine.

A demonstration of the preparation and collection of iodine.

A comparison of the properties of chlorine, bromine, and iodine.

Reference to fluorine — its importance in dental health.

Compounds of nitrogen. (7 periods)

The properties of nitrogen.

Laboratory preparation of nitric acid; its acid properties when diluted; its oxidizing action when concentrated; its uses; its toxic effect.

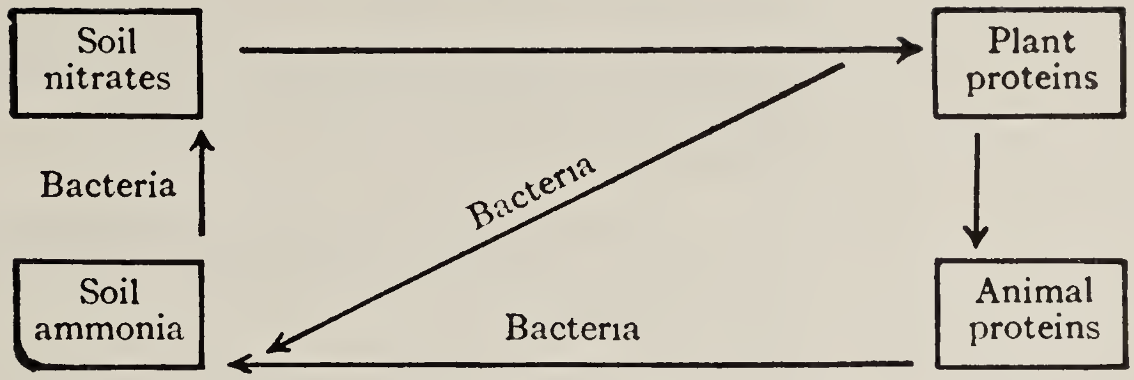
The properties and uses of such nitrates as those of sodium potassium, ammonium, and calcium.

The brown-ring test for nitrates.

Test for nitrates in soils.

Laboratory preparation of ammonia; its properties and uses. Properties of a solution of ammonia.

Brief discussion of the formation and properties of such ammonium salts as ammonium chloride and ammonium sulphate. Nitrogen and soil fertility — simple explanation of the nitrogen cycle.



Inert gases.
(2 periods)

The presence of rare gases in the air. Discuss their chemical inactivity and commercial uses. Commercial source of helium.
Briefly discuss the history of the discovery of these gases, emphasizing the importance of precise and painstaking research.

Calcium and magnesium.
(6 periods)

The reaction of calcium with water.

Occurrence of calcium carbonate (limestone and marble).

Heating of calcium carbonate. The commercial preparation of quicklime. The slaking of quicklime.

Commercial uses of limestone, quicklime, slaked lime, gypsum, bleaching powder, calcium chloride.

Test for calcium in soils. Liming soils.

Occurrence of magnesium in dolomite. Reference to Canadian production in Renfrew county (Pidgeon Process).

Properties of magnesium.

It should be emphasized that the metal is resistant to oxidation at ordinary temperatures; only the ribbon or wire forms of magnesium are readily ignited. Importance of magnesium in making low-density alloys such as magnalium.

Rates of reactions.
(3 periods)

Throughout the course attention of students should be directed to instances of the following factors influencing the rates of reactions:
(1) heat (2) light (3) concentration (4) surface area (5) catalysis. At the conclusion of the course a recapitulation of this topic should be made.

Industrial chemistry.

A class which is situated near an industry which uses chemical processes should make a study of those processes whenever practicable in order to make students realize that chemical reactions are the basis of many of our industries.

Soils.
(8 periods)

Soil profile: examination of a soil profile in the field; distinction between surface soil and subsoil; discussion of character of subsoil in relation to drainage, moisture retention and root penetration.

Plant nutrients in soils. The essential nutrients for plant growth obtained from the soil. A brief discussion of plant

nutrients in soil with special attention to those required by plants in larger amounts and which may commonly be deficient; functions of the four major nutrients in plant growth.

Comparison of the amounts of nitrogen, phosphorus, potassium and calcium removed by crops and lost by leaching from the soil.

Organic matter and nitrogen; the importance of organic matter (humus) maintenance in relation to physical condition, moisture-holding capacity and supply of nitrogen in the soil.

Organic matter the storehouse of soil nitrogen: nitrogen made available by decomposition, ammonification and nitrification; addition of nitrogen by nitrogen fixation by legume bacteria; free fixation by azotobacter and by rainfall (nitrogen cycle).

The value of crop residues, farm manures and green manures for supplying organic matter in the soil.

Soil conditioners.

Manure and commercial fertilizers. (10 periods)

Review the meaning of the terms "nitrogen", "phosphoric acid" and "potash" as used in reference to manure and commercial fertilizers; the importance of farm manure as a fertilizer; losses in storage and methods of conserving plant nutrients in manure.

Examination of the following materials used alone or in mixtures to supply nitrogen, phosphoric acid and potash: nitrate of soda or sulphate of ammonia, calcium cyanamide, superphosphate, bone meal; muriate of potash or sulphate of potash.

Tests to show the relative solubility in water and the presence of nitrate, ammonium or organic nitrogen in the nitrogen fertilizers; of water-soluble phosphate in super-phosphate or bone meal, and of water-soluble potash in muriate of potash or sulphate of potash.

The Fertilizers Act, Sections 1, 2, 3, 4, 5, and 9.

Materials used in control of insects, plant diseases and weeds. (3 periods)

Characteristics and uses of Bordeaux mixture, lime sulphur, copper carbonate, arsenates of lime and lead, DDT, and 2-4-D.

Note 1. — It is suggested that chemistry be taken systematically for all periods through the topic on fuels, then topics on poultry and dairying for one or two periods a week concurrently with chemistry and that topics on soils, manures and fertilizers, and materials be taken at the end of the course.

Note 2. — The allotment of periods is based on six periods per week in the forty-five period time-table generally used in schools teaching agriculture.